

MULTIMEDIA



UNIVERSITY

STUDENT ID NO

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MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2019/2020

EPM4086 – DIGITAL CONTROL SYSTEMS
(RE)

14 OCTOBER 2019
9.00 a.m – 11.00 a.m
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This Question paper consists of 6 pages with 4 Questions only.
2. Attempt **ALL** out of **FOUR** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please write all your answers in the Answer Booklet provided.
4. Table of Transform Pairs has been included in Appendix.

Question 1

- (a) What is “Analog to Digital Converter”?

[2 marks]

- (b) The following signals are sampled by an ideal sampler with sampling period T . Evaluate the starred transform $F^*(s)$.

$$f(t) = 5te^{2t}$$

[5 marks]

- (c) Find the z-transform and inverse z-transform of the following functions of (i) and (ii) respectively.

(i) $F(s) = \frac{8}{s^2(s+5)}$

(ii) $F(s) = \frac{1}{z(z-0.5)}$

[5 marks]

[5 marks]

- (d) Given the difference equation as,

$$x(k+2) + 3x(k+1) + 2x(k) = e(k)$$

Where $x(0) = 1$, $x(1) = -1$, and

$$e(k) = \begin{cases} 1, & k = 0 \\ 0, & \text{otherwise} \end{cases}$$

- (i) Solve for $x(k)$ as a function of k .

[6 marks]

- (ii) Evaluate $x(0)$ and $x(1)$ in part (i).

[2 marks]

Continued ...

Question 2

(a) In the digital control system, define the following

(i) Zero-state response

[2 marks]

(ii) Zero-Input response

[2 marks]

(b) Consider the following discrete characteristic equation,

$$F(z) = z^3 + 3az^2 + 2az - 0.6$$

(i) Find the range of a such that $F(z)$ satisfies the preliminary Jury Test.

[5 marks]

(ii) What is the condition of stability?

[5 marks]

(c) A discrete control system which is shown in **Figure Q2(c)** has a plant transfer function

$$G_p = \frac{20(s+3)}{(s+4)(s+5)}$$

Where $H(s) = 1$ and $T = 0.1$ sec.

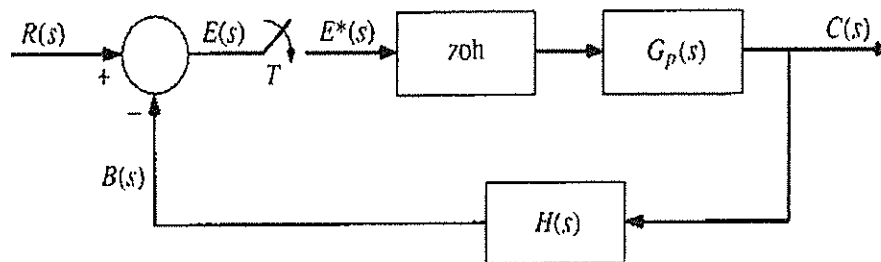


Figure Q2(c)

(i) Find the position error constant (K_P), the velocity error constant (K_V), and the acceleration error constant (K_A).

[8 marks]

(ii) Determine the steady state error when the input applied is unit step, unit ramp and unit parabolic.

[3 marks]

Continued ...

Question 3

- (a) For the discrete-time system modeled by the following dynamic equations.

$$x(k+1) = Ax(k) + Bu(k)$$

$$y(k) = Cx(k)$$

Where $A = \begin{bmatrix} 1 & 1 \\ 0.5 & 4 \end{bmatrix}$, $B = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$, $C = [1 \quad 1]$

- (i) Determine the transfer function $Y(z)/U(z)$.

[7 marks]

- (ii) Design the state diagram of the system.

[8 marks]

- (b) **Figure Q3(b)** shows the block diagram of the servo control system and $D(z) = 1$. Determine the transfer function of the closed loop system with sampling period $T = 0.25$ sec.

[10 marks]

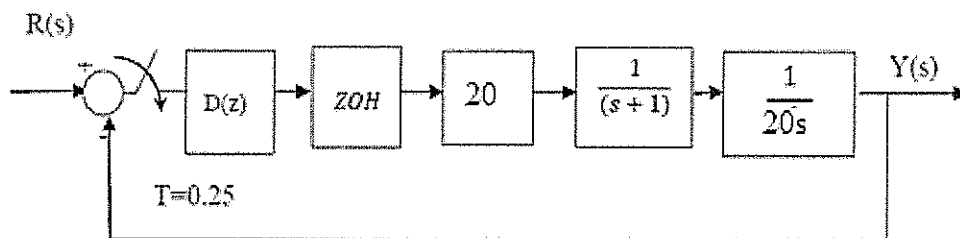


Figure Q3(b)

Continued ...

Question 4

- (a) State the characteristics of deadbeat controller.

[6 marks]

- (b) A system has the plant as

$$x(k+1) = \begin{bmatrix} 1 & -0.5 \\ -0.5 & 2 \end{bmatrix} x(k) + \begin{bmatrix} 2 \\ 1.5 \end{bmatrix} u(k)$$
$$y(k) = [1 \quad 1] x(k)$$

- (i) Test the system controllability.

[4 marks]

- (ii) Test the system observability.

[4 marks]

- (c) Design a state-feedback control $u(k) = -kx(k)$ which places the closed loop characteristic roots at $\pm j\frac{1}{2}$. The system is presented in state space form as

$$x(k+1) = \begin{bmatrix} 2 & -1 \\ -1 & 1 \end{bmatrix} x(k) + \begin{bmatrix} 4 \\ 3 \end{bmatrix} u(k)$$
$$y(k) = [1 \quad 1] x(k) + 7u(k)$$

[11 marks]

Continued ...

APPENDIX
TABLE OF TRANSFORM PAIRS

Time function $f(t); t > 0$	Laplace Transform $F(s)$	Z-transform $F(z), T = \text{Sampling time}$
$u_s(t)$	$1/s$	$z/(z-1)$
t	$1/s^2$	$Tz/(z-1)^2$
t^2	$2/s^3$	$T^2z(z+1)/(z-1)^3$
ε^{-at}	$1/(s+a)$	$z/(z-\varepsilon^{-aT})$
$1-\varepsilon^{-at}$	$a/\{s(s+a)\}$	$z(1-\varepsilon^{-aT})/\{(z-1)(z-\varepsilon^{-aT})\}$
$t\varepsilon^{-at}$	$1/(s+a)^2$	$Tz\varepsilon^{-aT}/(z-\varepsilon^{-aT})^2$
$\sin at$	$a/(s^2+a^2)$	$z \sin aT/(z^2-2z \cos aT+1)$
$\cos at$	$s/(s^2+a^2)$	$z(z-\cos aT)/(z^2-2z \cos aT+1)$
$\varepsilon^{-at} \sin bt$	$b/\{(s+a)^2+b^2\}$	$z\varepsilon^{-aT} \sin bT/(z^2-2z\varepsilon^{-aT} \cos bT+\varepsilon^{-2aT})$
$\varepsilon^{-at} \cos bt$	$(s+a)/\{(s+a)^2+b^2\}$	$(z^2-z\varepsilon^{-aT} \cos bT)/(z^2-2z\varepsilon^{-aT} \cos bT+\varepsilon^{-2aT})$

End of Paper